Marko Uršič

University of Ljubljana, Slovenia

Łukasiewicz's idea of temporary limited causal chains and the problem of symmetry between past and future

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Let me use at the beginning the same apology as Jan Łukasiewicz himself in his inauguration address *On Determinism* (1922/1946). Łukasiewicz said:

> I should like to confess in advance that I am unable to examine this problem, in all its details, with the scientific precision that I demand from myself. What I give is only a very imperfect essay, of which perhaps somebody will one day take advantage to establish, on the basis of preliminary examinations, a more exact and mature synthesis. (Łukasiewicz 1970, 112)

Łukasiewicz had in mind the problem of determinism which occupied so many illustrious minds in the past and is still one of the most important issues of philosophy today. Łukasiewicz's definition of determinism is the following:

(D) By determinism I understand the belief that if *A* is *b* at instant *t* it is true at any instant earlier than *t* that *A* is *b* at instant *t*. (*Ibid.*, 113)

I would like to point out that the essential part of this definition is *time*: if some event is determined in Łukasiewicz's sense, it means that it is determined *in advance*, at *any instant earlier* than the instant of its occurring. Łukasiewicz explains:

> If everything that is to occur and become true at some future time is true already today, and has been true *from all eternity*, the future is as much determined as the past and differs from the past only in so far as it has not yet come to pass. (*Ibid.*, italics by M.U.)

This *temporal* qualification of determinism, which is also plausible from the intuitive point of view, should be outlined since in some recent definitions of determinism time is supposed not to be so essential, as for example in Smith & Oaklander (1995, 143):

> *Causal determinism*: For every event that occurs there is some condition (event) or set of conditions (events) sufficient to bring about that event.

In this definition time is not even mentioned, and the problem of "causal determinism" is reduced to a presence or absence of sufficient conditions for some event just before or even at the very instant of its occurring, and not necessarily in *any* instant earlier. This reduction may lead, if we are not careful enough, to the neglecting of the distinction between determinism and the principle of causality. If this distinction is not clear enough, then it is easy to argue for compatibility of "determinism" and free will, but to my mind such argumentation misses the point.[1] Distinction between determinism and causality is essential, as points also Peter van

[1] Some compatibilistic argumentation is the following, for example: "Even if the tenseless view did entail determinism, which it does not, it would not follow that such a view entails that the future history of the universe

Inwagen in his *Essay on Free Will*:

> *Determinism* may now be defined: it is the thesis that there is at any instant exactly one physically possible future. ... Determinism in this sense must be carefully distinguished from what we might call the Principle of Universal Causation, that is, from the thesis that every event (or fact, change, or state of affairs) has its cause. (Inwagen 1983, 3)

Considering the problem of determinism, as defined above (D), Łukasiewicz tries to reject "two arguments of considerable persuasive power which have been known for a long time and which seem to support determinism" (Łukasiewicz, *op. cit.*, 114): 1. the so-called logical argument for determinism, namely that the principle of bivalence implies determinism; 2. the metaphysical argument, based on the assumption that causal chains are infinite in time. Here I shall not consider the former, since it was treated so many times in modern philosophical logic, but I will concentrate in the latter argument which is supposed by its proponents to be "based on the principle of causality" (see Łukasiewicz, *ibid.*, 117).

Łukasiewicz's notion of causality is founded on the following, quite classical suppositions (see *ibid*., 118):

> 1. causality is a *relation* between *cause* and *effect* which are "facts... connected with each other by means of known laws..." (instead of "facts" we may use the term *events*, in accord with current terminology[2]);
>
> 2. the instant when a cause occurs is *earlier* than the instant when its effect occurs (i.e., Humean priority of cause before effect);
>
> 3. causal relation is *transitive*.

After confirming these suppositions, Łukasiewicz defines the *principle of causality*:

(C) I understand by the principle of causality the proposition that every fact *G* occurring at instant *t* has its cause in some fact *F* occurring at instant *s* earlier than *t*, and that at every instant later than *s* and earlier than *t* there occur facts which are both effects of the fact *F* and causes of the fact *G*. (*Ibid.*, 118)

It is evident here again that in Łukasiewicz's conception of causality time plays an essential role. Definition (C) has two interesting features: first, it takes into account the possibility of temporarily *finite* causal sequences, and second, it establishes the *continuity* of causal sequences in time.[3]

In the following Łukasiewicz argues that the principle of causality (C) does *not* entail determinism (D). Entailment from (C) to (D) only seems to be valid, if we wrongly infer in this way:

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pre-exists in the present, since determinism does not imply that the future is already laid up in the present. ...In other words, the existence of causally sufficient conditions for the future does not imply that the future is present." (Smith & Oaklander 1995, 141-142)

[2] Łukasiewicz says: »Every fact takes place somewhere and at some time.« (*On Determinism*, *op. cit.*, 118). The term 'event' is closer to this concept.

[3] Łukasiewicz uses the term "causal sequence", not the term 'causal chain' as recent authors usually do. Here we do not need a sharp distinction between these two terms, so we use mostly the term 'causal chains', but we follow Łukasiewicz speaking of "causal sequences" when he compares them with mathematical *sequences*.

> Since according to the principle of causality every fact has its cause in some *earlier fact*, this procedure can be repeated over and over again. Therefore, we obtain an *infinite sequence* of facts which extends back /in time/ infinitely [...] because the facts take place at *ever earlier instants*. (*Ibid.*, 119; italics by M.U.)

According to Łukasiewicz, we could not infer from infinite sequence of facts (i.e., causes and effects, events forming a causal chain) to infinite extension of this sequence in (past) time. His proposal rejects this inference by introducing a hypothesis that an *infinite sequences of causes might have its limit in time*:

> There is an error in the argument which derives the thesis of determinism from the principle of causality. For it is not the case that if John is at home tomorrow noon, then the infinite sequence of causes of this fact must reach the present and every past instant. This sequence may have its lower limit at an instant later than the present instant: one which, therefore, has not yet come to pass. (*Ibid.*, 120)

It is interesting to notice that for Łukasiewicz it is out of question that time-limited sequences of causes could be *infinite*. "These facts are infinitely many," he wrote (*ibid.*, 119). However, it cannot be taken for granted that a limited time interval can actually contain infinitely many facts. I will return to this point below.

The first question to be asked here is: which arguments or evidences support the hypothesis of causal *time limits* themselves? Alas we have no conclusive philosophical arguments, and even less scientific evidences for this claim yet. In spite of all recent developments in science, especially in quantum mechanics, temporary limited causal chains remain just a metaphysical conjecture, a modern version of *creatio ex nihilo*, endlessly repeated in time. Łukasiewicz, more that half a century ago, thought that his conjecture was "clearly implied" by an analogy, found in *mathematics*: as infinite sequences in mathematics can have lower or upper limits in the continuum of real numbers, so causal sequences, even those with infinite number of "facts", might be limited in the continuum of time. But this is no more than an analogy which *might* obtain, an analogy which is motivated by philosopher's endeavors to justify free will:

> This reasoning shows that there might exist infinite causal sequences which have not yet begun and which belong entirely to the future. This view is not only logically possible but also seems to be more prudent than the belief that each, even the smallest, future event has its causes acting from the beginning of the universe. [...] One can be strongly convinced that nothing happens without cause, and that every fact has its cause in some earlier fact, without being a determinist. (Łukasiewicz, *ibid.*, 121).

However, on the other hand, if Łukasiewicz's conjecture of temporarily limited causal sequences were justified, this would be the strongest and most decisive argument against determinism, since other arguments are much more elusive and in some cases also circular. Peter van Inwagen (1983), for example, whose strategy of refuting determinism is in some traits similar to Łukasiewicz's argumentation, argues that there are three premises – all far from being obvious – which we have to presume, if we want to deduce determinism from the principle of causation:

> (1) if an event (or fact, change, state of affairs, or what have you) has a cause, then its cause is always itself an event (or what have you) and never a substance or continuant,

such as a man;

(2) if an event (or what have you) *A* was the cause of an event *B*, then it follows, given that *A* happened and given the laws of nature, that *A* 'causally *necessitated*' *B*, that *B* could not have failed to happen;

(3) every chain of causes that has no earliest member is such that, for every time *t*, some event in that chain happens earlier than *t*. (Peter van Inwagen 1983, 4)

The premise (1) seems to be implicitly circular, namely: *if* some cause exists which (who) is *not* an event, but "a substance or continuant, such as a man" – i.e., a genuine free agent, *creator* – then we do not need to argue against determinism, since the agent's free will is taken for granted, included *in adiecto* in the concept of this free "substance", or *Subjekt* in the sense of classical "continental" philosophy. On the other hand, if the alleged "continuant" is such that his or her mental states are themselves causally related, "chained" (and that could be expected), then the problem of determinism is just transposed into the level of mental events and their connections with physical events. Otherwise said, the negation of Inwagen's premise (1) itself, if true, would entail indeterminism. – And it is similar with the premise (2): it alone, if true, would entail determinism. – So, after all, the only relevant (not circular) premise which has to be presumed in order to entail determinism from the principle of causation is the premise (3) which is equivalent with the negation of Łukasiewicz's conjecture of time limits of causal sequences. Actually, Łukasiewicz took the problem of determinism 'by its horns' - in spite of lack of evidence for his conjecture.

Beside Łukasiewicz's general frame of the discussion of causality (i.e., Humean frame: event causality, priority of cause before effect, transitivity of causal relations; see also points 1-3 above), there are some other implicit presuppositions of his concept of causal relation which he himself did not reflect. One of them is the classical idea that causal chains could be, at least in principle, isolated and represented as *linear* structures. This model is problematic, for it might be the case that causal structures are not at all linear, but integrated in lattices or even more complex structures, so that they could not be taken out of these structures, not even in principle. It might be the case that an event in some "chain" brings about another only if combined with events of other "chains", satisfying some "threshold condition" which might be a property of the complex structure as a whole.[4]

Nevertheless, let's assume, for the sake of simplicity, the classical view that causal chains can be modeled as linear structures and represented by mathematical sequences, as in Łukasiewicz's argumentation. But then we come to another problem - namely, could an *isomorphism* between *instants* (in time) and *events* (in causal chains) be established at all? Let's say that for every event there is some instant in time - however, does *vice versa* also hold? This is more problematic. If we model instants of time with real numbers (or points on a line) which form a continuum, how could *every* real number (or a point) correspond to *some* event? This might be possible only in case if events have no dimension, like points in geometry. Indeed, in Minkowski's four-dimensional continuum events are defined as "points" in space-time, but it is not at all obvious that this mathematical (and relativistic) concept of event could be used in

[4] Recent discoveries in neurology and computer science ("neural networks" etc.) support the idea that mental processes are holistic, so that isolated mental states (or "inner events") could not be linearly ordered.

philosophical theories of causality.

Events in causal contexts – Łukasiewicz's "facts" – are members of causal chains, causes and effects. Are they "point-like"? Probably not. From the intuitive point of view, an event in the causal sense is something that should require some (even very small) amount of energy. It is known from quantum mechanics that energy could not be emitted in any small quantities because of its quantized nature. If events in causal sense (Łukasiewicz's "facts") require some energy to occur, it follows that also events themselves could not be divided *ad infinitum*. There might be *quanta of events*, and in this case infinity of events in some limited time interval becomes a problem which has to be solved before accepting Łukasiewicz's conjecture.[5] If causal events are quantized, the analogy with mathematical sequences becomes very dubious. It seems that in this case we are confronted with the dilemma: either infinite causal sequences extend infinitely in space-time, without any lower and upper time-limits, or, if such limits do exist, then causal sequences do *not* contain *infinite* number of events. In the latter case, namely if events in a sequence are finite by number, they must have some *first* event, *causa prima* (relative to a chain) - and this means also *causa sui*, either as an absolute agent, a (self)creator, or as some miracle of (self)creation *ex nihilo*. From the history of philosophy and theology is well known that *causa sui* is the last what can be said in a rational explanation, and it explains nothing.

So, let us see if there is some other possible explanation and support for indeterminism, by following – however modifying – Łukasiewicz's way of thinking. Is there some way to avoid the alternative between miracles of continuous, endlessly repeated *creatio ex nihilo*, implied by Łukasiewicz's time-limited causal sequences, and determinism which has, according to Łukasiewicz, as its necessary condition infinite extension of causal sequences in time? Do infinite and time-*un*limited causal sequences necessarily entail determinism in the sense, defined by Łukasiewicz (D)? I think they do not.

To show this, I propose the following simple model, based on an analogy between quantum mechanics and theory of causation. The basic, however tentative concept of this model is *event-quantum*: let us suppose that causal events are "quantized", i.e., not just "points" in space-time, but "quanta" with some minimal amount of energy. If we accept this supposition, we may say – in analogy with quanta in physics – that event-quanta are twofold by character: "particle-like" and "wave-like". The particle-likeness of event-quanta is their "executive causal force" (or, classically said, moving cause, *causa efficiens*); the wave-likeness of event-quanta yields continuity of causal chains. Next we introduce a new concept, *event-field*, as extension of event-quanta (their sets, sequences etc.) in space-time. (It can be understood as an epistemic term, nevertheless, in the background there is also an analogy with fields in physics.) Then an *observer* is put into the event-field, where he or she has a "privileged" location with zero-coordinates. We go on by defining *density* of an event-field as an average space-time interval among events at some space-time location (region). Now, two concepts of density of an event-field have to be distinguished: proper density and coordinate density. *Proper* density is density of events in the local sense, namely density just in that region of an event-field where an observer takes place and time; it is of course relative to the chosen observer, since it depends of

[5] One may speculate that "quanta of events" have some property like spin, and that its value enables any number of them to take the same space-time location etc., but this is one more questionable conjecture.

how many events are happening just around him or her at a certain time. *Coordinate* density of an event-field is a ratio of proper density and the square of space-time distance (interval) between the observed part of the field and coordinates of the observer; it is also local (since it depends of proper density and relative to the chosen observer), but in another sense, namely relative to the distance in space-time.

For our context, we may reduce space-time intervals just to distances of events in *time*. If we define *period* as a measure of time (minute, day, year, millennium etc. are periods), then the coordinate density of some past period decreases with distance of that period, relative to the observer. If we suppose that in a long term proper density of events is constant (like, for example, density of matter in cosmology), then, going back in time, we come to some period without any event in it. For that period it may be said that the *coordinate* density of its event-field is zero – it is *empty*. (Of course it does not mean that its proper density is null.) If we go back far enough, the *first empty period* may have any length, from one minute or less to many million years or more.

> AN EXAMPLE: Take as a convention that such a length of a period is chosen which is equivalent with an average proper distance between two successive events in time. If the average proper distance between two successive events in our time-region is, let's say, one year, we take the period to be one year long. But if our time-period is considered to be the so-called historical time, i.e., time back to some 3000 B.C., period of one year would be too long, since from our historical coordinate in time, 1996 A.D., we know (let's say, collectively remember, but this is not the point here) more than one event per year for the past five millennia. However, if we proceed back to the time of dinosaurs, the period of one year has to be enlarged - relative to our coordinate of time - namely, to thousands or even millions of years. And, if we go still further back to the past, we come later or sooner to the first empty period (period without any event, observed from our time-coordinate, so its coordinate density is zero); we come to some zero (coordinate) density period regardless how large a period has been initially chosen.

So, we may ask, how could this model help in solving the problem of determinism? It may show to us how the determination of some event, from the epistemic point of view, is *relative* to the coordinates of this event, dependent of the *coordinate* density of its causal sequence. If we go far back in time, causal sequences become less and less dense - and so the question whether they have the first member (*causa prima*) or not, becomes irrelevant. For some chosen observer causal chains might be finite or infinite sequences of events, but in both cases they "fade out", if he or she follows them far enough into the past. We may say that every past sequence of events, from the perspective of some chosen time coordinate – which for us, finite beings, is the *only* actual perspective – at a certain distance "fades out", its coordinate density collapses to zero. Or, we may say: going backwards in time, from the point of view of a present observer, causal sequences have less and less "executive force".

How can determinism (D) be refuted in this model? It is easy to show that criterion (D) is not satisfied, if we go back in time to the first (or any earlier) *empty period* of the causal sequence in question. Let us take a causal sequence $\boldsymbol{S}$ and name its first empty period p_ε and an instant in this period t_i . If A is b at instant t_0 (we may take t_0 as the time coordinate of the observer), it is *not* the case that it is true at *any* instant earlier than t_0 that A is b at t_0 , since at the earlier instant

t_i in the (first) empty period p_ε of $\boldsymbol{S}$ there is *no* event of the causal sequence $\boldsymbol{S}$ which would by its "particle-like" nature (by causing subsequent events, as *causa efficiens*) bring about that A is b at instant t_0. On the other hand, the "wave-like" nature of other event-quanta in the sequence $\boldsymbol{S}$ yield its continuity, so that some variant of the principle of causality (C) could be satisfied.

And how can these considerations be applied to the question of symmetry between past and future? At the end of his address *On Determinism* Łukasiewicz has pointed out: "We should not treat the past differently from the future" (Łukasiewicz 1922/1946, 127) – but could we really justify this symmetry? It is known that the question of symmetry opens the idea of "bringing about the past" and the general problem of realism vs. antirealism (Dummett 1978, and others). My opinion is that Łukasiewicz's problem of determinism and the problem of symmetry between past and future times are two *separate* problems, since the latter requires an answer whether anisotropy of time obtains or not, while the former is not dependent of this issue. Here I will not go on with discussion on this difficult topic, I just want to show in short why the symmetry of past and future does not go through the proposed model.

At first sight it seems that from the formal point of view, the model of event-field might be symmetrically applied to future time in the sense that causal sequences would "fade out" not only far in the past but also far in the future. For example: let's choose an observer from the time of dinosaurs and name him *Dino*, and take into account some causal sequence $\boldsymbol{S}_d$ which was important in his life and continued after his death; this sequence has "faded away" up to our time, far remote in future for *Dino* when he was alive; if we take one year as a period, we may say that in the year 1996 A.D. there is *no* more event of the sequence $\boldsymbol{S}_d$ – i.e., this is an empty period (maybe not just the first) of $\boldsymbol{S}_d$, in respect of coordinate density relative to the observer *Dino*. In Łukasiewicz terms, this sequence contained past "facts whose effects have disappeared altogether, and which even an omniscient mind could not infer from those now occurring, /so that they/ belong to the realm of possibility" (Łukasiewicz, *op. cit.*, 128). – However, there is one trouble with this symmetry of past and future, namely: *every* future period (not only some year very far in the future, but also next year etc.) is *empty* for an observer in present or past times – and so, for the observer from the times of dinosaurs, for *Dino,* every future period was empty, not only the very remote future year 1996 A.D. So the symmetry of past and future is not satisfied by our model: from the point of view of a present observer his or her coordinate event-density for any future period of time is zero. All future is an empty event-field.

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